Appendix 5-B
Methods and Information Resources for Use in Analyzing Landscapes and Wetlands

This appendix presents methods and general references regarding analysis of the landscape and its wetlands as well as assessment of the characteristics and functions of individual wetlands. It includes a brief description of the approach that the Department of Ecology is developing for analyzing the landscape. Appendix 5-C contains examples of Ecology's landscape analysis as conducted in the City of Leavenworth and in Whatcom County. Chapter 5 of this volume presents a number of questions, regardless of the method used, that should be answered when conducting landscape analysis.

Methods for analyzing the larger geographic scales (contributing landscape, management area) are, however, only starting to be implemented in Washington to assist local governments in developing plans, regulations and non-regulatory approaches to protect landscape processes and wetlands. Therefore, there is very little information about the effectiveness of these methods at providing the information necessary to manage and protect wetlands from this broader perspective.

On the other hand, methods for analyzing the functions and characteristics of individual wetlands have been extensively tested in Washington State. Numerous methods are summarized in this appendix.

References on Landscape Scale Processes in the Pacific Northwest

The following books are recommended for developing an understanding of landscape processes in the coastal region of the Pacific Northwest. Though these books focus on riverine ecosystems, the concepts, principles, and research presented are very useful in understanding the interaction of processes that occur at larger geographic scales with all wetland types.

Naiman, R. and R. Bilby (eds.). 1998. *River Ecology and Management: Lessons from the Pacific Coastal Ecoregion.* Springer-Verlag, New York. 705 pgs.

From the publisher's abstract:

> *Touching all parts of the natural environment and nearly all aspects of human culture, streams and rivers act as centers of organization within landscapes. They provide natural resources such as fish and clean water,*

transportation, energy, diffusion of wastes, and recreation. A basic ecological understanding of the structure and dynamics of running waters is needed to formulate sound management and policy decisions. The vast Pacific coastal ecoregion of the United States contains an extraordinary array of physical setting and examples of the range of dynamics associated with rivers and their management. The interface between the science and policy of natural resource management is illustrated by examples from this ecoregion, including the protection riparian forest, the marbled murrelet, salmon, and amphibians. This study includes sections on the physical environment, the biotic environments, ecosystem processes, management, and recommendations for the future. Specific topics include channel dynamics, hydrology, water quality, microbial process, primary production, fish and wildlife, riparian forest dynamics, organic matter and trophic dynamics, biogeochemical cycling, maintaining biodiversity, monitoring and assessment, economic perspectives, legal consideration, and the role of non-governmental organizations in river management.

In particular, Chapters 2 through 4 in Part I (Physical Environment), Chapters 11 and 12 in Part III (Ecosystem Processes), and Chapters 19 and 20 in Part IV (Management) are very useful in understanding landscape processes and how to approach assessment at a watershed scale.

Montgomery, D., S. Bolton, D. Booth, and L. Wall (eds.). 2003. *Restoration of Puget Sound Rivers.* University of Washington Press. 512 pgs.

From the publisher's abstract:

In the Pacific Northwest, as in most regions of the United States, we are still learning about the processes that create habitat and river structure, how those processes influence aquatic ecosystems, and how to gauge the response of river systems to both land-use change and restoration efforts. River systems are still responding to historic changes, and degraded habitat may not be restored successfully if natural conditions are not well understood, particularly if massive change in watershed hydrology or other processes are the root cause….The eighteen chapters of Restoration of Puget Sound Rivers – presented by the region's experts at a symposium of the Society for Ecological Restoration – examine geological and geomorphological controls on river and stream characteristics and dynamics, biological aspects of river systems in the region, and the application of fluvial river systems in the region, and the application of fluvial geomorphology, civil engineering, riparian ecology, and aquatic ecology in efforts to restore Puget Sound Rivers.

In particular the first five chapters of this book are very useful in gaining an understanding of landscape processes and the effect of alterations on these processes.

The reference also addresses potential objectives for restoration based on landscape setting, geology, and land uses.

General References for Analysis at a Landscape Scale

The following books provide some general information about tools for analyzing wetlands and aquatic resources at the larger geographic scales. These may provide useful background information to anyone trying to develop an approach that will work in their jurisdiction.

Kroenert, R., U. Steinhardt, and M. Volk 2001. *Landscape Balance and Landscape Assessment*. Springer-Verlag, New York. 304 pgs.

Abstract from the publisher:

> *During the last decades, landscape ecology has developed tremendously. It concerns both the theoretical basis and practical application. The authors follow a hierarchical approach that is inherent in landscape structures and processes as well as in planning practice. They show first approaches for the inclusion of factors of the landscape balance into planning procedures and new methods (GIS-coupled modeling, remote sensing) combined with more classical approaches from the basis of landscape assessment. Approaches for multi-criterial landscape assessments will be presented also. The overall target is to give recommendations for sustainable land-use and management. Each chapter concludes with a synthesis of the theme under discussion. Ideas concerning the state-of-the-art are integrated as well as future trends in research. All methodological approaches will be explained with examples from differing regions.*

Heathcote, I.W. 1998. *Watershed Management: Principles and Practice.* John Wiley & Sons, Inc. 414 pgs.

Abstract from the publisher:

> *This book presents a flexible, integrated framework for watershed management that addresses the biophysical, social, and economic issues affecting water resources and their use. Comprehensive in scope and multidisciplinary in approach, it equips you with the necessary tools and techniques to develop sound watershed management policy and practice - from problem definition and goal setting to electing management strategies and procedures for monitoring implementation. Topics include watershed components and processes; establishing management plan parameters and objectives; stakeholder identification and consultation; development of practical management options; both simple and detailed methods for the assessment of management alternatives; techniques for determining the legal implications and the environmental, economic, and*

social impact of a management plan; and choosing the best plan and putting it into action. Supplemented with case studies and examples, Integrated Watershed Management is an ideal resource for upper-level students and professionals in environmental science, natural resource management, and environmental engineering.

Reimold, R.J. 1998. *Watershed Management: Practice, Policies, and Coordination.* McGraw-Hill Companies. 608 pgs.

Abstract from the publisher:

Ensuring a safe and adequate supply of water requires the combined efforts and expertise of resource managers, engineers, planners, technical experts, and policy analysts worldwide. This contributed volume is unique in recognizing this need and provides today's first truly comprehensive, international coverage of effective watershed management. Experts representing the full spectrum of environmental professions and viewpoints provide detailed case studies of how watershed management is being implemented around the world, focusing on the United States, France, the former Soviet Union, the Pacific Rim, the Nile River, and other areas. Successful approaches such as whole watershed and full stakeholder involvement; watershed sanitary surveys; urban watershed management; river basin planning; integrated management and water resource protection; watershed-based coastal management wetlands restoration; water quality monitoring and assessment; stormwater and other nonpoint pollution source management; water withdrawal; wastewater discharge permitting; and other tools for cost-effective watershed management are highlighted. Mathematical models demonstrate how various systems can be successfully managed for future sustainability.

Methods for Analyzing the Contributing Landscape and Management Area

The following list identifies a few methods that have been suggested or used for providing information that can be used in managing and protecting wetlands at the larger geographic scales.

EPA Synoptic Approach

Abbruzzese, B., and S.G. Leibowitz. 1997. A synoptic approach for assessing cumulative impacts to wetlands. *Environmental Management* 21(3): 457-475.

Leibowitz, S.G., B. Abbruzzese, P.R. Adamus, L.E. Hughes, and J.T. Irish. 1992. *A synoptic approach to cumulative impact assessment: A proposed methodology.* U.S. Environmental Protection Agency. EPA/600/R-92/167.

One of the case studies used to demonstrate the concept of the synoptic approach is Washington State. Abstract (from the authors):

> *The U.S. Environmental Protection Agency's Wetlands Research Program has developed the synoptic approach as a proposed method for assessing cumulative impacts to wetlands by providing both a general and a comprehensive view of the environment. It can also be applied more broadly to regional prioritization of environmental issues. The synoptic approach is a framework for making comparisons between landscape subunits, such as watersheds, ecoregions, or counties, thereby allowing cumulative impacts to be considered in management decisions. Because there is a lack of tools that can be used to address cumulative impacts within regulatory constraints, the synoptic approach was designed as a method that could make use of available information and best professional judgment. Thus, the approach is a compromise between the need for rigorous results and the need for timely information. It is appropriate for decision-making when quantitative, accurate information is not available; the cost of improving existing information or obtaining better information is high; the cost of a wrong answer is low; there is a high demand for the information; and the situation calls for setting priorities between multiple decisions versus optimizing for a single decision. The synoptic approach should be useful for resource managers because an assessment is timely; it can be completed within one to two years at relatively low cost, tested, and improved over time. An assessment can also be customized to specific needs, and the results are presented in mapped format. However, the utility of a synoptic assessment depends on how well knowledge of the environment is incorporated into the assessment, relevant to particular management questions.*

Department of Ecology's Landscape Approach

Ecology has developed an approach that characterizes landscape processes through an understanding of patterns of water flow and the movement of sediment, nutrients, and toxic compounds. It is based on research that landscape processes drive wetland structure and function. Patterns of water flow are described using several GIS-based data layers including landscape setting, topography, geology, and soils. Once water flow patterns are mapped and described, the relationships between landscape processes and both historic and existing wetland resources can be established. The approach also includes steps to describe existing and future alterations to landscape processes, and identification/ranking of wetland restoration areas and appropriate land use activities.

The purpose of Ecology's approach is to

- Provide information that can be used to sustain and restore ecosystems;
- Establish a common environmental framework for coordinating planning efforts;
- Assist in preparation of comprehensive plan and Shoreline Master Plan updates:
  - Provide direction on appropriate designations for land use and zoning;
  - Promote integration of the Growth Management Act and Shoreline Management Act (SMA);
  - Establish a framework for characterizing environmental processes and developing a restoration plan as required under the new SMA guidelines; and
  - Promotes "no net loss" of shoreline functions.

The Ecology approach involves the following five steps. The steps and accompanying checklists are to be used in conjunction with a PowerPoint tutorial, which is available online at: www.ecy.wa.gov/programs/sea/landscape.

1. Identify priority planning areas.
2. Characterize processes of water flow:

   2.1 Map geologic formations and identify relative level of permeability for each (if possible develop understanding of how surficial geology was formed).

   2.2 Develop plan view map of groundwater flow patterns using topography and contour lines.

   2.3 Identify other factors and their effect on water flow patterns (faults, precipitation patterns, etc.). Use historic information to assist in developing maps.

   2.4 Develop regional profile of groundwater flow.

   2.5 Summarize natural water flow processes.

3. Identify impacts to natural water flow processes from current land use.
4. Identify future development conflicts.
5. Identify compatible land uses and restoration areas measures.

Maryland Stream Corridor Assessment Survey

The following description was taken from the survey web page in April 2004: http://www.dnr.state.md.us/streams/stream_corridor.html

> *The Stream Corridor Assessment (SCA) survey was developed by DNR's Watershed Restoration Division as a tool to help environmental managers identify environmental problems and prioritize restoration opportunities on a watershed basis. As part of the survey, trained personnel walk the watershed's entire stream network and record information on a variety of environmental problems that can be easily observed within the stream corridor. Common environmental problems documented in the survey include: eroding stream banks, inadequate stream buffers, exposed pipes, altered stream channels, fish migration barriers, pipe outfalls, in-stream construction sites and trash dumping locations. In addition to identifying the location of common stream problems the survey also collects information on both in- and near-stream habitat conditions so that comparative assessments can be made of the condition of different stream segments.*
>
> *It is important to note that Stream Corridor Assessment Survey is not intended to be a detailed scientific evaluation of a stream system nor will it replace the more standard chemical and biological surveys. Instead the survey is intended to provide a rapid method of examining an entire drainage network so future monitoring and management efforts can be better targeted. Part of the need for this type of survey is that many existing scientific surveys are very time consuming, expensive and can only collect information for a relatively small section of stream at any one time. The Stream Corridor Assessment Survey, on the other hand, is designed so that teams of 2 or 3 volunteers are able to survey 2 or more stream miles per day. Individuals performing the survey receive training in both stream ecology and how to conduct the survey.*

North Carolina Coastal Region Evaluation of Wetland Significance (NC-CREWS)

Sutter, L.A. and J.R. Wuenscher. 1996. *NC-CREWS: A Wetland Functional Assessment Procedure for the North Carolina Coastal Area (Draft)*. Division of Coastal Management, North Carolina Department of Environment and Natural Resources, Raleigh, NC. 61 pgs./appen.

The following description was taken from the NC-CREWS web page in April 2004: http://www.wes.army.mil/EL/emrrp/emris/emrishelp6/north_carolina_coastal_region_evaluation_of_wetland_significance_tools.htm. Note that this method was developed to rate wetlands in North Carolina. The indicators of function used would have to be modified to reflect conditions in the region of Washington where the method is being used.

> *Primary purpose: To predict the relative ecological significance of wetlands within their watershed and region using a GIS-based landscape-scale procedure. Developed for use in planning and overall management of wetlands rather than for regulatory decisions.*

Eleven functions are addressed: surface runoff storage; floodwater storage; shoreline stabilization; terrestrial wildlife; aquatic life; nonpoint source; floodwater cleansing; landscape character; water characteristics; replacement difficulty; and restoration potential.

Procedure: Using GIS analysis, a High, Medium, or Low rating is assigned to each of 39 parameters that describe the landscape and internal wetland characteristics. The parameter ratings are successively combined to produce ratings (H, M, or L) for subfunctions and primary functions. The primary function ratings are combined to form an overall rating of the wetlands ecological significance (i.e., beneficial significance, substantial significance, or exceptional significance).

Output: Measure of overall ecological significance of a wetland within its watershed and the larger landscape.

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Limitations listed by authors: "The NC-CREWS models should not be used as a guide to design, however, individual variables (parameters) may provide useful information. It is not the intended purpose for the procedure, therefore, it contains properties that limit its application for this purpose. For example, NC-CREWS uses opportunity variables, but does not set upper limits on those opportunities that could potentially reduce functional capacity (e.g., a wetland located near a pollutant generating area is assigned a high rating). In some circumstances, a wetland may not have the capacity to remove all nutrient input. An upper limit on the opportunity must be defined to insure that the existing or planned wetland can predictably have the capacity to provide a function."

Spatial Wetland Assessment for Management and Planning (SWAMP)

Sutter, L.A., J.B. Stanfill, D.M. Haupt, C.J. Bruce, and J.E. Wuenscher. 1999. *NC-CREWS: North Carolina Coastal Region Evaluation of Wetland Significance.* North Carolina Division of Coastal Management, Department of Environment and Natural Resources. Raleigh, NC.

The following description was taken from the SWAMP web page in April 2004: http://www.csc.noaa.gov/lcr/swamp/text/p661.htm#intro. Note that this method was developed to rate wetlands in North Carolina. The indicators of function used would have to be modified to reflect conditions in the region of Washington where the method is being used. Ecology is presently working to adapt this method the coastal region of the Pacific Northwest.

The Spatial Wetland Assessment for Management and Planning (SWAMP) uses basic ecological principles to evaluate the significance of wetlands within a watershed while allowing the decision maker to establish the rules for overall rating. The model is based on the NC-CREWS model (Sutter et al. 1999) but has significantly faster processing time and offers greater flexibility in adjustment of parameters and rating rules. Three groups of functions are evaluated including water quality, hydrology and habitat.

Procedure: Requires digital information in GIS format. including:(1) wetland boundaries and types; (2) land cover; (3) soils data; (4) hydrography; and (5) watershed boundaries.

The functional significance of wetlands are rated (non quantitative) on the basis of three broad categories: exceptional functional significance, substantial functional significance, and beneficial functional significance.

Output: To produce information about the relative ecological importance of wetlands that would be useful for wetland planning and management..

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Limitations listed by the authors: The result of the procedure is not a substitute for a site visit in making regulatory decisions, but a predictor of what a site visit would determine. The parameters and thresholds developed for the ACE Basin would be more defensible if data had been collected to specifically support the assumptions behind each parameter.

Methods for Analyzing Wetland Sites

All projects involving impacts to wetlands will, at some level, be required to describe the functions provided by that wetland. The level of analysis will depend upon the type and scale of the proposed impacts, such that the detail necessary will be commensurate with the impacts.

If Ecology is involved in a project, the applicant will generally be requested to apply the *Washington State Wetlands Rating System* to determine the category of the wetland and how well it performs certain functions. Regulatory agencies may request that an applicant complete an assessment of functions if wetland impacts will be significant and the wetland is in one of the classes for which a *Washington State Wetland Function Assessment Method* exists (see below).

The following is a list of methods that were specifically developed to analyze wetlands in Washington or are commonly used in the state.

Washington State Wetland Function Assessment Methods (WAFAMs)

WAFAMs are a collection of assessment methods developed by interdisciplinary teams of experts and published by Ecology. The methods are based on the hydrogeomorphic (HGM) classification for wetlands.

Advantages

- Relatively rapid for the scientific rigor of the assessments that result.
- Provide a numeric expression of the level of performance of wetlands in regard to their potential to perform and their opportunity to perform some functions.
- Developed for specific areas in Washington and for specific wetland types.
- Peer reviewed and field tested in the area for which they were developed.
- Results are reproducible to ± 10%, especially with training.

Limitations

- Large, structurally complex sites may require a couple of days.
- Site visits at different times of the year may be necessary to accurately determine the water regime (e.g., the length and extent of inundation).
- Specific training in the application of WAFAM is required before one uses it for regulatory purposes.
- WAFAM methods are lacking for specific wetland types of Washington. Methods do not exist for riverine wetlands in eastern Washington, for any montane areas, or for any slope, tidal, or dunal wetlands.
- Numeric results may be misused to assume scores are continuous functions rather than discrete integers.

Recommended Uses

- Projects involving significant wetland impacts in terms of size (e.g., >2 acres) or estimated level of performance of the wetland.
- Determine if functions lost to impacts have been adequately replaced in compensatory mitigation

Washington State Wetlands Rating System

The rating system is technically a characterization that groups wetlands based on sensitivity, rarity, functions, and other criteria.

Advantages

- Designed to classify wetlands into one of four categories which allow agencies/local governments to determine how the wetlands should be protected and managed.
- Rapid and relatively easy to perform; the vast majority of sites can be rated within 1 to 2 hours in the field.

Limitations

- Not an assessment of functions, but a characterization.
- May oversimplify the performance of functions needed to understand the wetland ecosystem in order to protect it, especially in large wetlands having several HGM types within one boundary.

Recommended Uses

- To determine into which category a wetland is classified: often for regulatory purposes to determine buffer widths and ratios for compensatory mitigation.
- May provide sufficient characterization of potential functions for impacts to small (e.g., <1 acre) degraded wetlands when determining needs for compensation.

Wetland Functions Characterization Tool for Linear Projects

This method is also a characterization. It uses a list of criteria for each function to guide decision-making. It relies on professional judgment regarding the likelihood that the function is being performed. The tools is available online at: http://www.wsdot.wa.gov/environment/biology/docs/bpjtool.pdf

Advantages

- Provides documentation of the criteria and rationale used when applying best professional judgment to analyze functions.

- Can be very rapid when used by trained wetland ecologists.
- Can also be used to characterize a portion of a larger wetland when a wetland exists on multiple properties and access to all parts of the wetland is restricted.
- Based on WAFAM which corresponds to "best available science."

Limitations

- Can't determine the level at which a function may be performed to plan compensatory mitigation.
- This method should not be used to measure change over time or as the result of alterations (e.g., impacts or mitigation).
- Method is subjective and results may vary significantly based on the experience and expertise of the user.

Recommended Uses

- Rapid screening of many wetlands to determine best areas for development or roads.

Semi-Quantitative Assessment Methodology (SAM) (Cooke 2000)

This method has not been published but is available on the web at http://www.cookescientific.com/SAM%20Stuff/SAM2000.pdf

SAM is no longer recommended for use in Washington's wetlands. Better tools have been developed more recently. It is reviewed here because it is still used by some jurisdictions and wetland consultants.

SAM provides a rapid method for rating various wetland attributes, including functions, with high, medium, and low rating.

Advantages

- Easy to use and requires no specific training (some knowledge of wetland ecology would obviously be beneficial).
- Reproducible between users.
- Developed for western Washington.

Limitations

- Provides very general information.
- "Low" ratings miss many site-specific details that are important for protection and management.

- Allocates high ratings to large, rural, undisturbed wetlands, while smaller wetlands in urban areas rate lower.
- Should not be used for wetlands east of the crest of the Cascade Mountains

Wetland Evaluation Technique (WET) (Adamus et al. 1987)

WET is a rating method that was developed in the late 1980s by the U.S. Army Corps of Engineers in cooperation with Paul Adamus.

WET is no longer recommended for use in Washington's wetlands. Better tools have been developed more recently.

Wetland Values: Concepts and Methods for Wetlands Evaluation (Reppert)

This was one of the first methods developed to help determine how wetlands function in 1979. It is a rating that groups wetlands into high, medium, low based on "functional values."

This method is no longer recommended for use in Washington's wetlands. Better tools have been developed more recently.

Proper Functioning Condition for Lentic Areas (PFC)

PFC is a qualitative method to characterize streams, riparian areas, and riparian wetlands. It was developed by the Bureau of Land Management to assess how well the physical processes in a wetland are functioning. See *Riparian Area Management: Process for assessing proper functioning condition for lentic riparian-wetland areas.* U.S. Dept. of Interior, Bureau of Land Management, TR1737-11. 1994.

Advantages

- Provides good information for designing restoration of riparian wetlands.

Limitations

- Correct application of this method requires an interdisciplinary team of experts.
- Does not separate wetlands from the rest of the riparian ecosystem.
- Primarily for riparian wetlands.
- Not an assessment that can be used independently to rate, characterize, or assess wetlands and their functions.

Recommended Uses

Could be useful in combination with other assessment methods. For wetlands that are "functional - at risk" or "nonfunctional" the methods can help to identify what is lacking (vegetation, soil, water) and may provide guidance on the likelihood of improving the condition and what actions could be taken to improve the condition.

Best Professional Judgment (BPJ)

Application of BPJ is the most common method used to determine the functions that a wetland provides. Application of this method requires that a wetland biologist/consultant decide how well a wetland performs functions based on his or her own experience or knowledge.

Most methods are based to some degree on the best professional judgment of the individuals or the teams of individuals who developed them.

Advantages

- Can be very rapid.
- If the expert has local knowledge, the information on functions may be very specific to the region and wetland type.

Limitations

- Not reproducible.
- Can't track the criteria used to base the judgment unless they are carefully recorded.
- Reliability of results varies greatly with expertise.
- Easier to be biased in regard to functions for which the expert has more knowledge.

Recommended Uses

BPJ may be used in analyzing functions for small impacts where more intensive analysis is not warranted.

Hydrogeomorphic Approach (HGM) (Brinson et al. 1995)

This approach has been developed by the U.S. Army Corps of Engineers. The documents associated with this approach are available at:
http://www.wes.army.mil/el/wetlands/hgmhp.html

The HGM approach provides guidance on developing regional methods for analyzing functions. It was put forth by the Corps for use in Section 404 permitting. WAFAM is based on many concepts in this approach.

The HGM approach is not a method to assess, characterize, or rate wetlands.